[0103] A thin, uniform, continuous SiN film having a thickness of about 18 Å was deposited at 650°C at a pressure of 3 torr using remotely generated atomic nitrogen and a single six-second pulse of trisilane, as generally described above for Examples 80-82. The film was coated with epoxy, cross-sectioned and imaged using transmission electron microscopy (TEM), as shown in the TEM photomicrograph of Figure 9. The film/substrate interface was found to be essentially free of native oxide.

EXAMPLES 84-87

[0104] A series of epitaxial silicon films were deposited onto cleaned Si <100> substrates using trisilane at a deposition pressure of 40 Torr and various flow rates, and at the deposition temperatures and deposition rates shown in Table 7. High quality epitaxial silicon films were produced, as indicated by the χ-min values obtained from Rutherford Backscattering channeling spectra as shown in Table 7.

TABLE 7

No.	**Deposition Temperature (°C)**	**Deposition Rate (Å/min)**	**χ-min (%)**
84	550	47	2.7
85	600	50	3.1
86	600	145	2.9
87	650	460	3.2

[0105] It will be appreciated by those skilled in the art that various omissions, additions and modifications may be made to the processes described above without departing from the scope of the invention, and all such modifications and changes are intended to fall within the scope of the invention, as defined by the appended claims.

EXAMPLE 79-82

[0101] A series of Si-containing materials were deposited onto the native oxide of Si <100> substrates using trisilane and atomic nitrogen. Atomic nitrogen was generated remotely using a commercially available 800 watt microwave radical generator (MRG) and was supplied to the CVD chamber. Trisilane was supplied to the CVD chamber along with the atomic nitrogen via a bubbler using a nitrogen carrier gas at a flow rate of 5 slm (10 slm for Example 82), at the deposition temperatures shown in Table 6. Trisilane was introduced to the chamber either continuously (Example 79) or in pulses (Examples 80-82). Pulsed introduction was accomplished by continuously introducing atomic nitrogen, and introducing trisilane in pulses at intervals of about 1 minute and 30 seconds. Each of the trisilane pulses lasted about 6 seconds, under the flow conditions described above. Each of the resulting SiN films had a stoichiometry in the range of approximately $Si_{43}N_{54-56}H_{3-1}$.

[0102] Table 6 shows the thicknesses, refractive indices and hydrogen levels (atomic %) in the resulting SiN films. The SiN film of Example 79 was not uniform because it was significantly thicker at the center than the edge, and the measured refractive index varied significantly across the surface of the film (higher at center than edge). Uniformity was improved by using the pulsed processes of Examples 80-82. Uniform films can also be obtained using the continuous process by increasing the flow rate of atomic nitrogen and/or decreasing the flow rate of trisilane.

TABLE 6

No.	Process	Deposition Temp. (°C)	Film Thickness (Å) Center	Film Thickness (Å) Edge	Refractive Index	% H
79	Continuous	650	869	510	1.97-2.2	2
80	Pulsed	650	324	268	1.98	2
81	Pulsed	600	635	655	1.96	3
82	Pulsed	650	1115	1174	2.02	0.7

EXAMPLE 83

TABLE 5

No.	Pressure (Torr)	Temp. (°C)	Carrier	Silicon source / flow rate (sccm)	Deposition Rate, Å/min.	Si/N	%H	RI
64	20	675	N_2	Trisilane / 20	124	0.88	4	2.074
65	20	725	N_2	Trisilane / 20	149	0.85	4	2.034
66	20	725	N_2	Trisilane / 80	585	0.95	4	2.182
67	20	725	H_2	Trisilane / 80	611	1.0	2.2	2.266
68	20	775	N_2	Trisilane / 20	158	0.88	4	2.010
69	20	775	H_2	Trisilane / 20	117	0.88	3	1.999
70	20	775	N_2	Trisilane / 40	308	0.85	4	2.053
71	20	775	N_2	Trisilane / 80	582	0.88	4	2.101
72	20	775	H_2	Trisilane / 80	600	0.88	3.5	2.146
73	20	775	N_2	Trisilane / 160	1050	0.88	4	2.141
74	20	775	H_2	Trisilane / 160	1283	0.92	3.5	2.281
75	20	775	N_2	Trisilane / 80	346	nd	nd	2.006
76	100	775	N_2	Trisilane / 160	589	nd	nd	2.028
77	100	775	H_2	Trisilane / 160	244	nd	nd	2.012
78	100	775	N_2	Silane / 40	208	nd	nd	2.007

nd: not determined

[0100] The values for Si/N and %H were determined by Rutherford Backscattering (RBS). Figure 19 is a representative RBS spectrum (2 MeV He^{++}) of a silicon nitride sample deposited using trisilane at 775°C and 20 Torr. An ERD spectrum obtained using Elastic Recoil Detection (ERD) is shown in Figure 20. These Figures show both the raw data and simulations based on the RUMP modeling program that enable quantification of the silicon, nitrogen, and hydrogen concentrations. The simulations indicate that the film has a stoichiometry of about $Si_{45}N_{51}H_4$. The RBS ERD spectrum shown in Figure 17 also reveals that the hydrogen is distributed uniformly throughout the film.

FIGURE 4

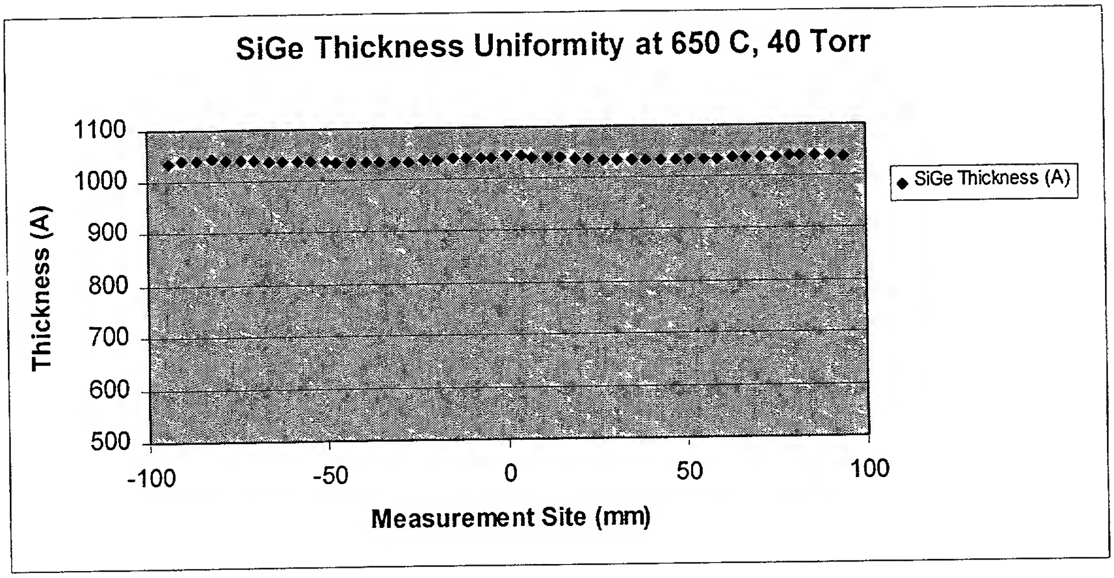

SiGe Thickness Uniformity at 650 C, 40 Torr
Thickness (A)
1100
1000
900
800
700
600
500
-100
-50
0
50
100
Measurement Site (mm)
SiGe Thickness (A)

FIGURE 5

SEM Photomicrograph of Si-Ge Film Deposited Using Silane and Germane

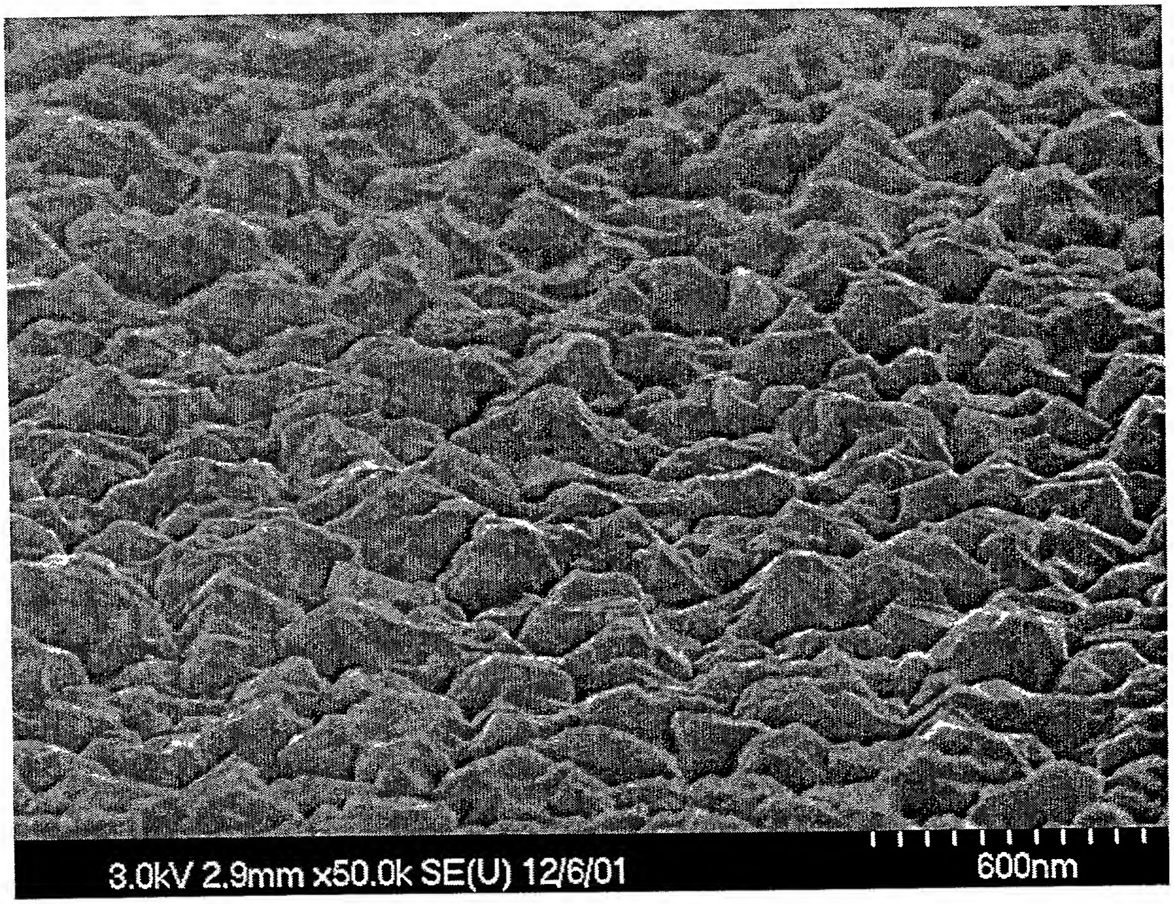


FIGURE 6
SEM Photomicrograph of Si-Ge Film Deposited Using Silane and Germane

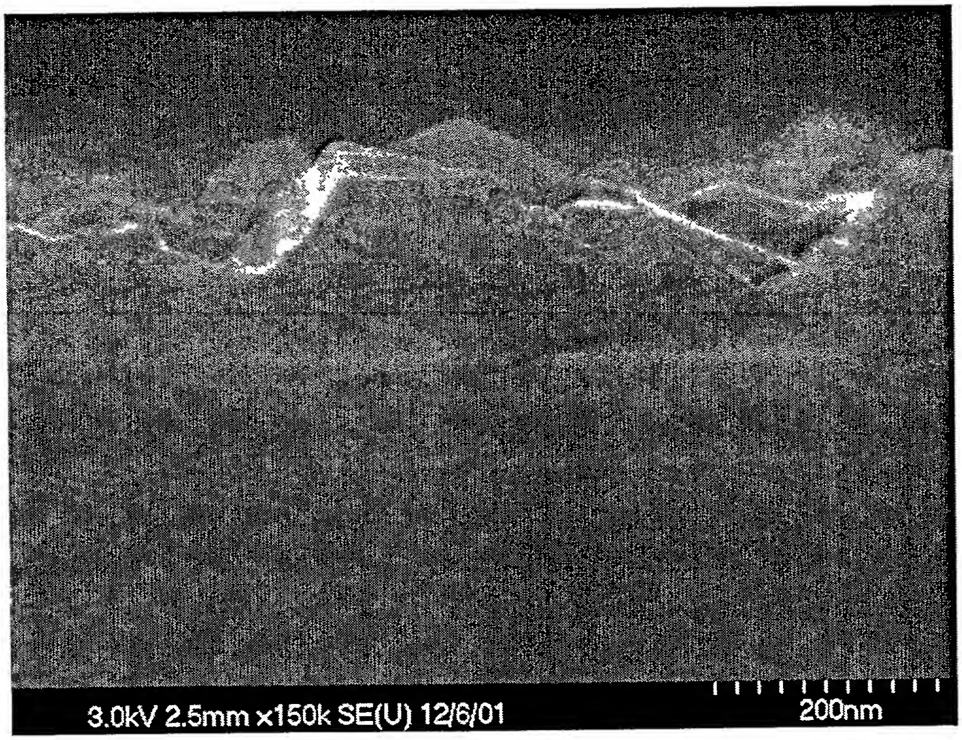


FIGURE 7
SEM Photomicrograph of Si-Ge Film Deposited Using Trisilane and Germane

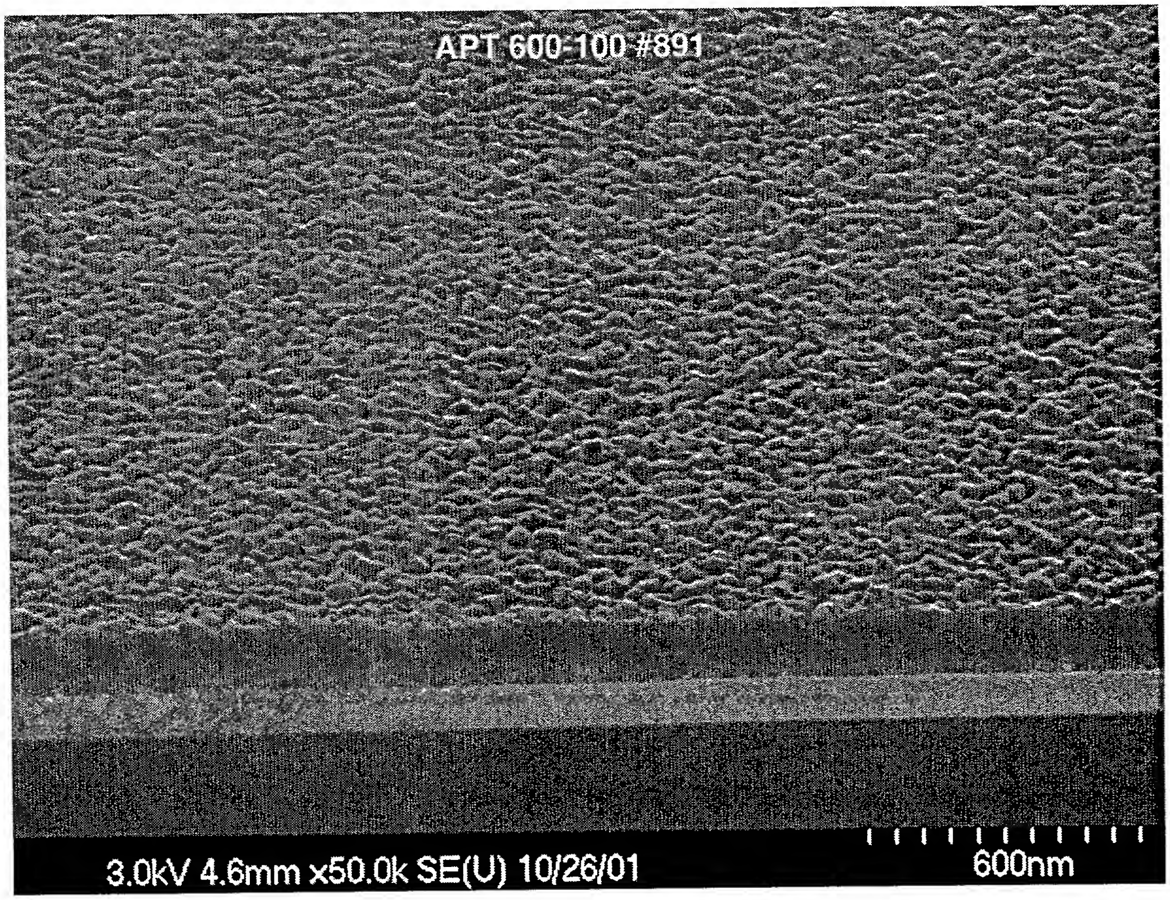


FIGURE 8

SEM Photomicrograph of Si-Ge Film Deposited Using Trisilane and Germane

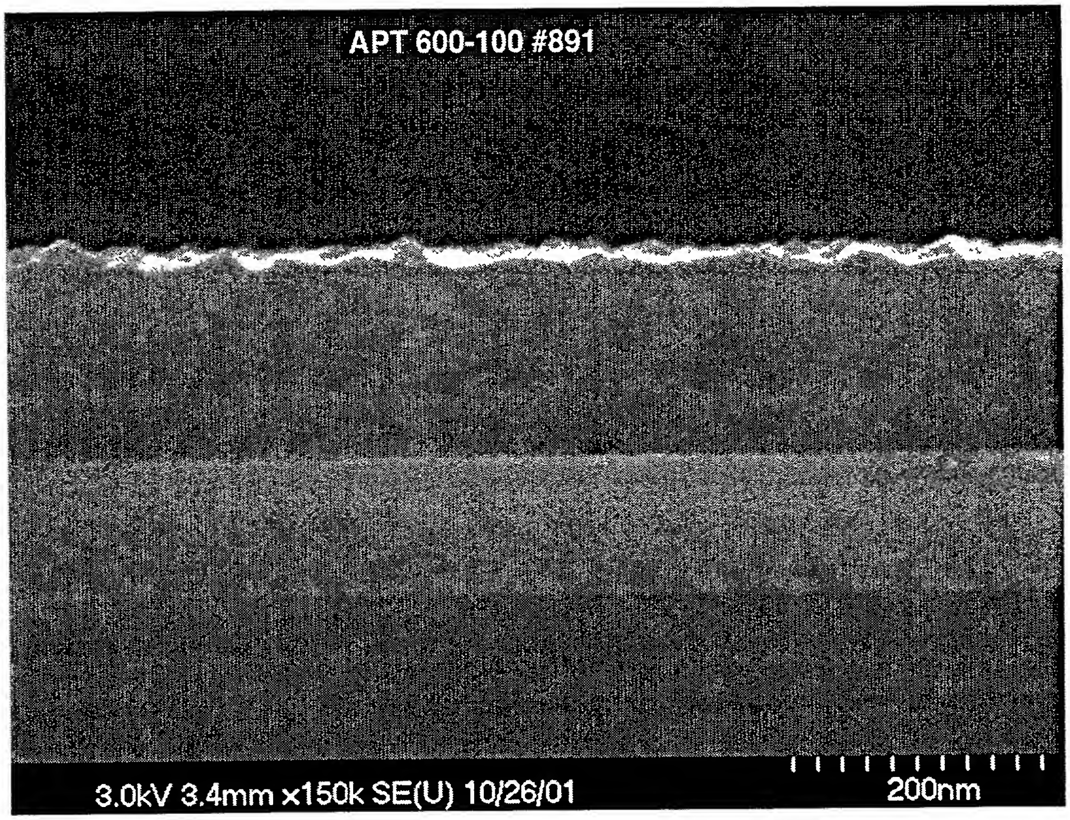


FIGURE 9

TEM Photomicrograph of Si-N Film Deposited Using Trisilane and Atomic Nitrogen

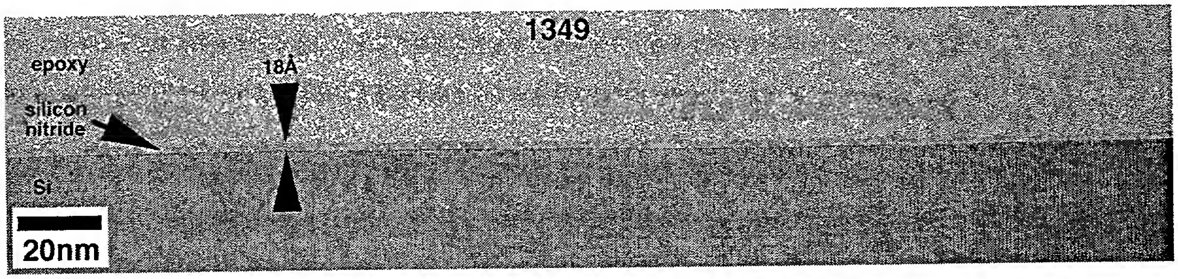


FIGURE 10

ARRHENIUS PLOT FOR SILANE, DISILANE AND TRISILANE

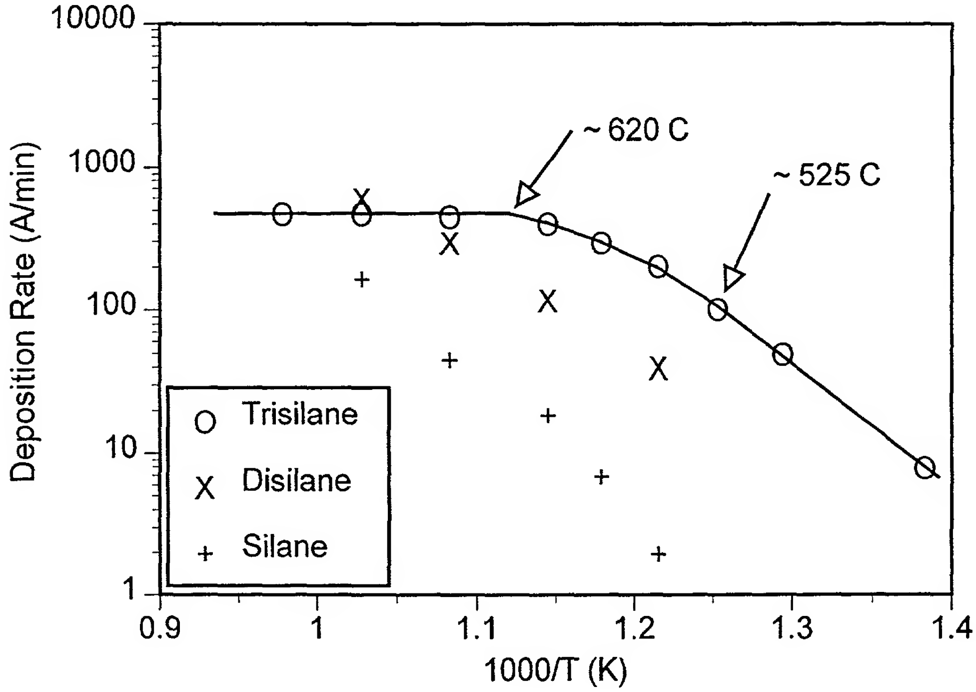
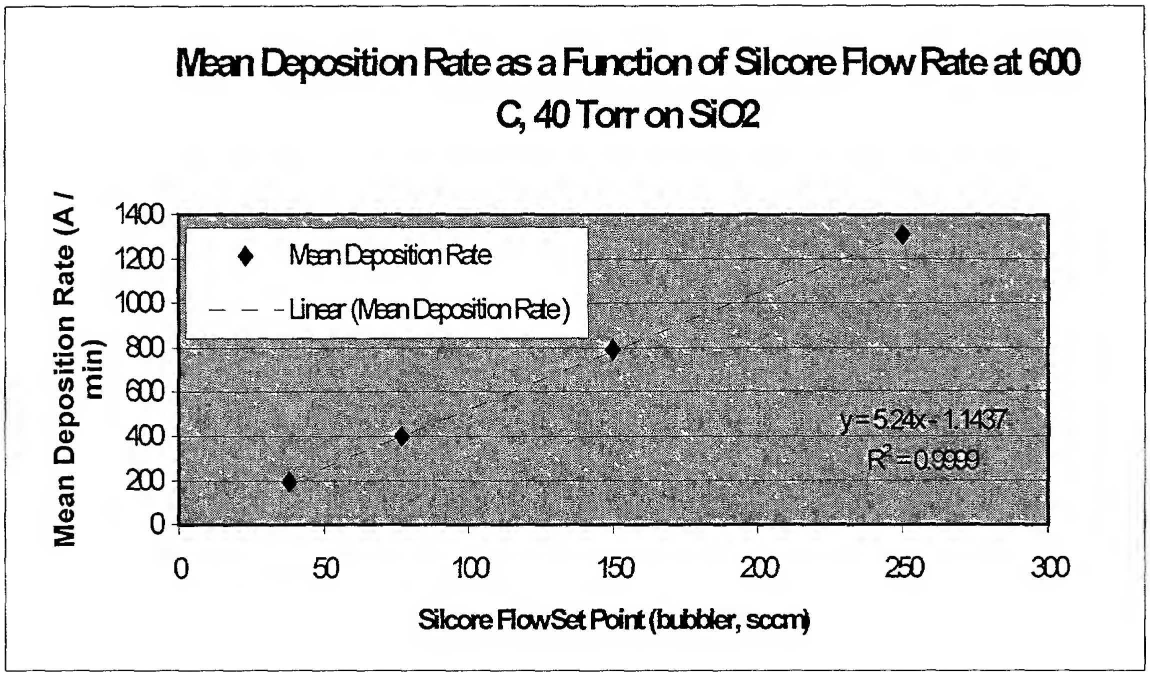


FIGURE 11



Mean Deposition Rate as a Function of Silcore Flow Rate at 600 C, 40 Torr on SiO2
Mean Deposition Rate (A / min)
1400
1200
1000
800
600
400
200
0
Mean Deposition Rate
Linear (Mean Deposition Rate)
y = 5.24x - 1.1437
R2 = 0.9999
0
50
100
150
200
250
300
Silcore FlowSet Point (bubbler, sccm)

FIGURE 12

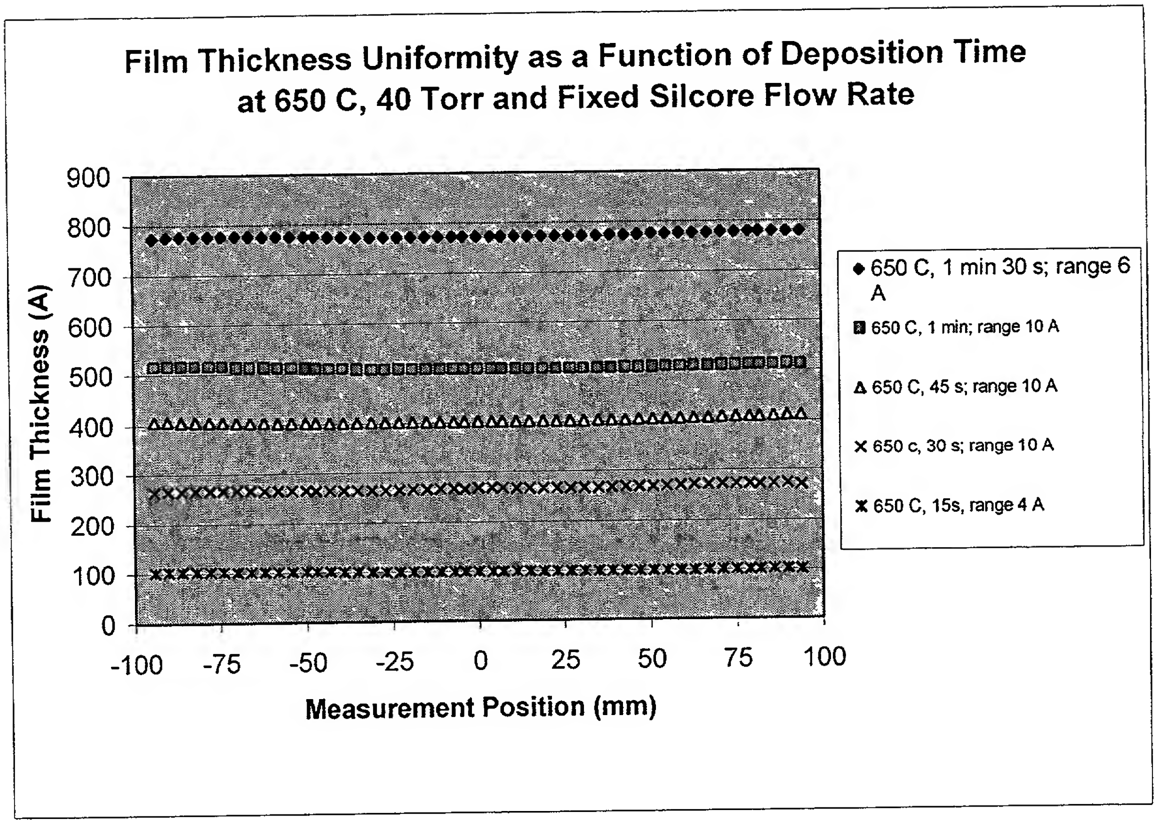

Film Thickness Uniformity as a Function of Deposition Time at 650 C, 40 Torr and Fixed Silcore Flow Rate
Film Thickness (A)
900
800
700
600
500
400
300
200
100
0
-100
-75
-50
-25
0
25
50
75
100
Measurement Position (mm)
650 C, 1 min 30 s; range 6 A
650 C, 1 min; range 10 A
650 C, 45 s; range 10 A
650 c, 30 s; range 10 A
650 C, 15s, range 4 A

FIGURE 13

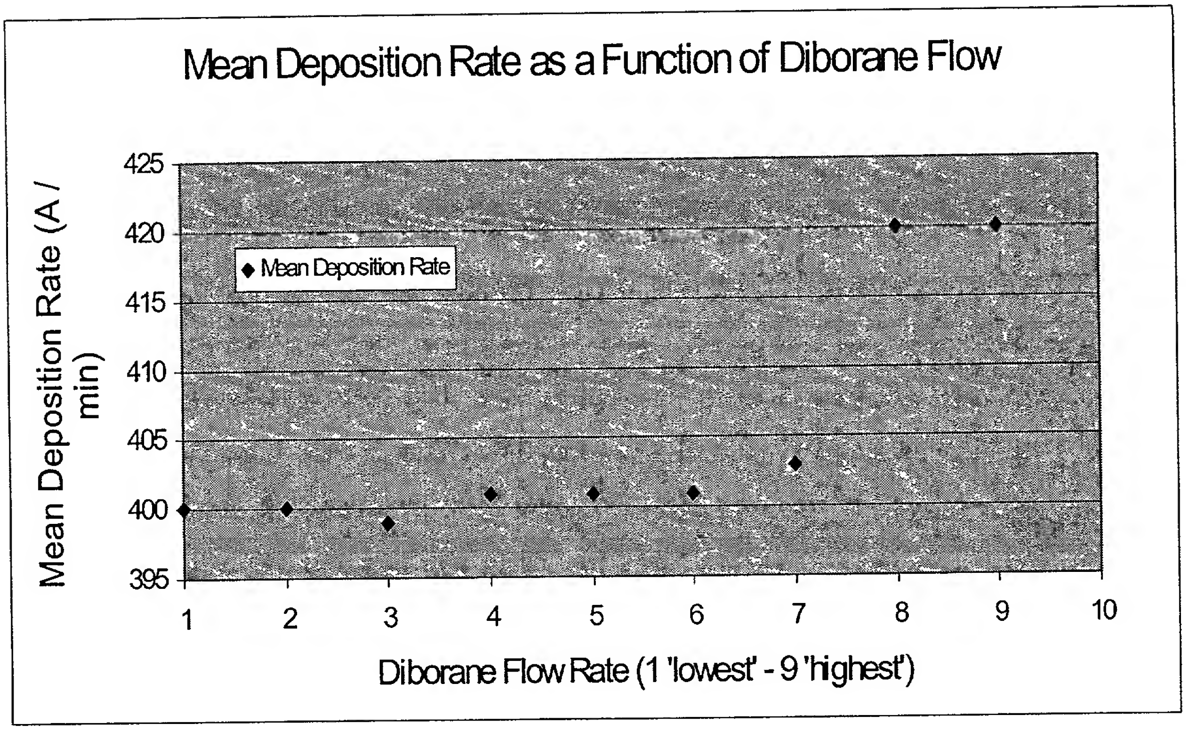

Mean Deposition Rate as a Function of Diborane Flow
Mean Deposition Rate (A / min)
425
420
415
410
405
400
395
Mean Deposition Rate
1
2
3
4
5
6
7
8
9
10
Diborane Flow Rate (1 'lowest' - 9 'highest')

FIGURE 14

RBS ERD SPECTRUM OF AMORPHOUS SILICON FILM DEPOSITED USING TRISILANE AT 600°C, 40 TORR

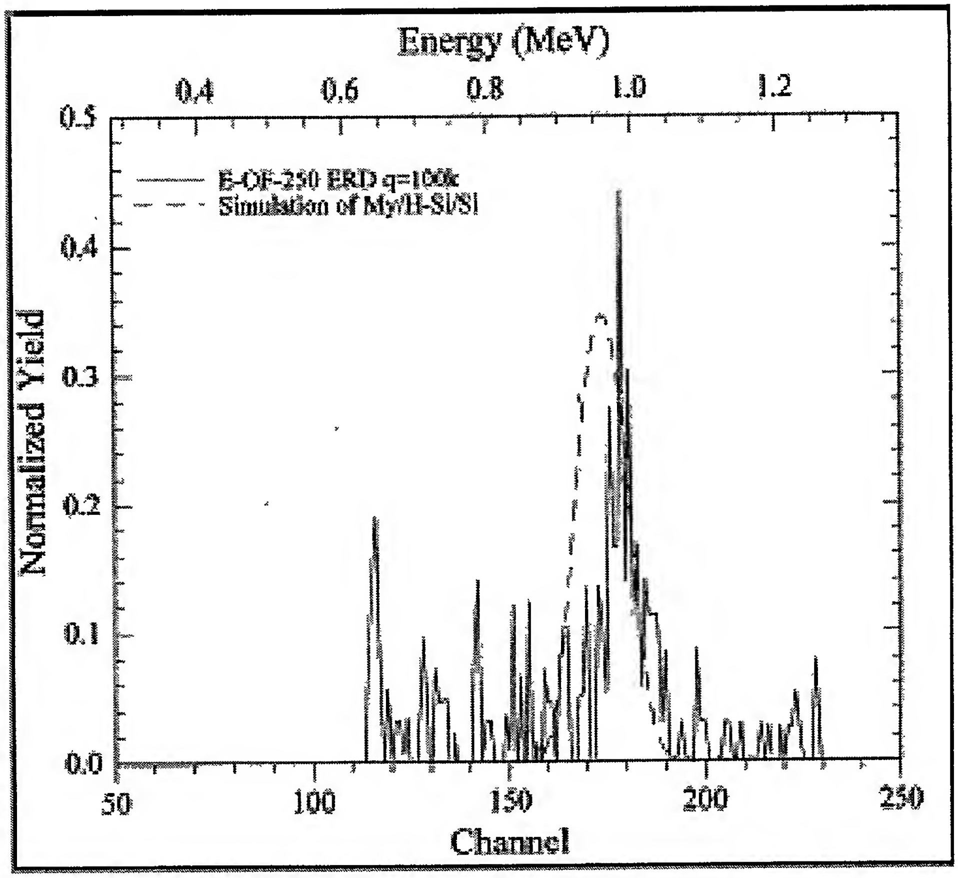


FIGURE 15

X-RAY DIFFRACTION SPECTRA FOR FILMS DEPOSITED USING TRISILANE AT 600°C, 650°C, 700°C AND 750°C (BOTTOM TO TOP, RESPECTIVELY)

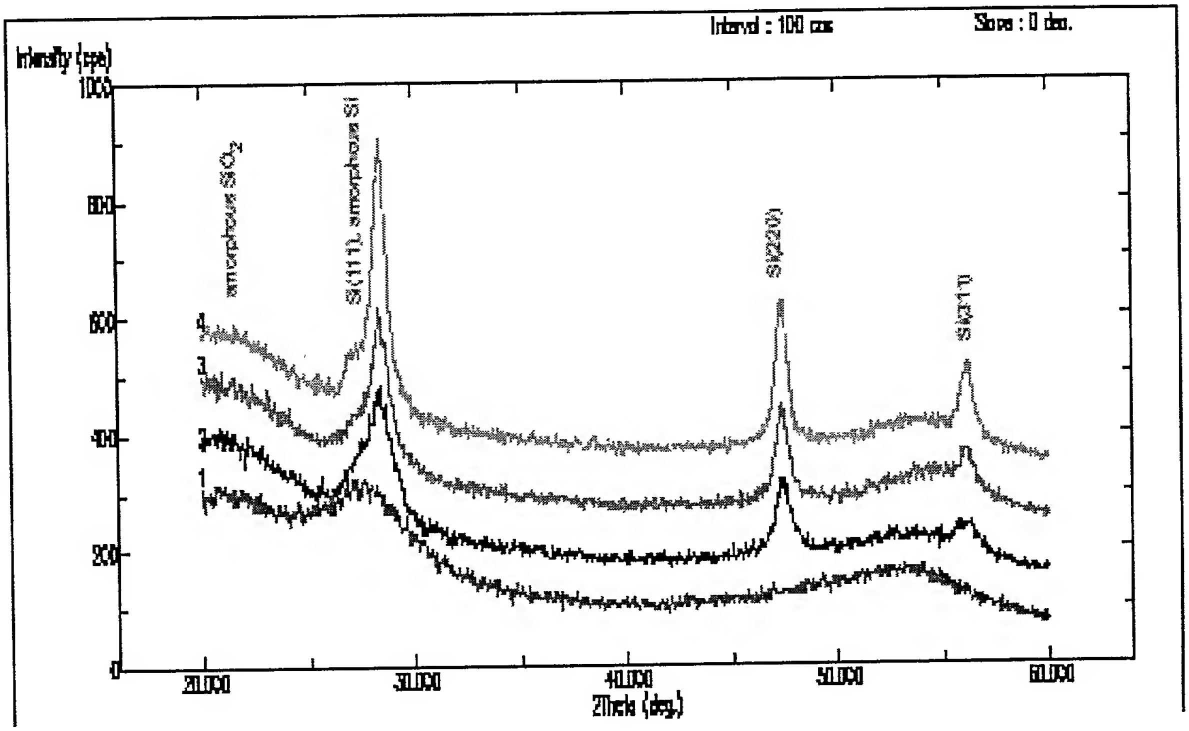


FIGURE 16

CROSS SECTION OF POLYCRYSTALLINE SILICON FILM

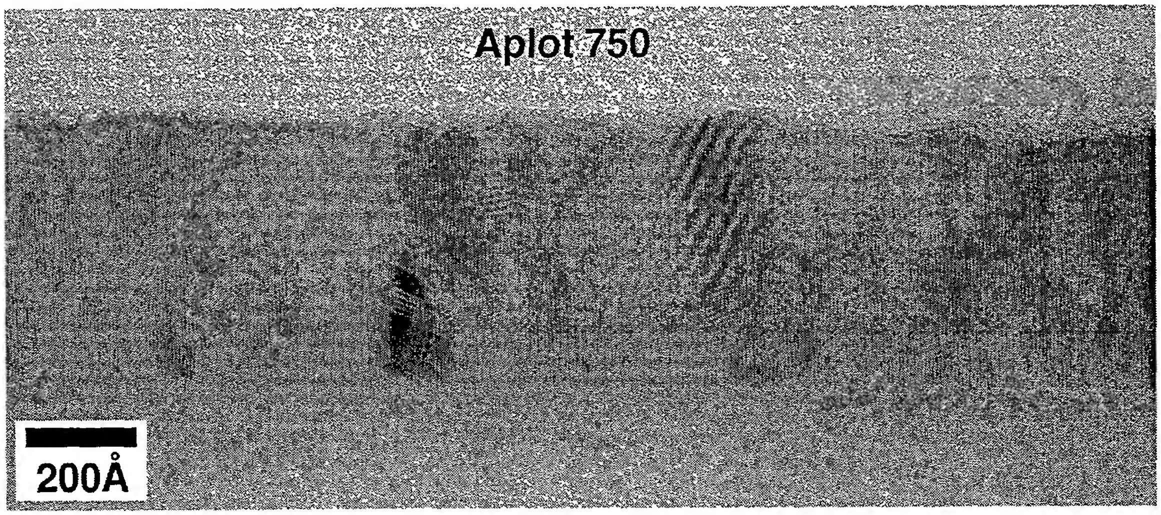


FIGURE 17

SAD PATTERN OF POLYCRYSTALLINE SILICON FILM

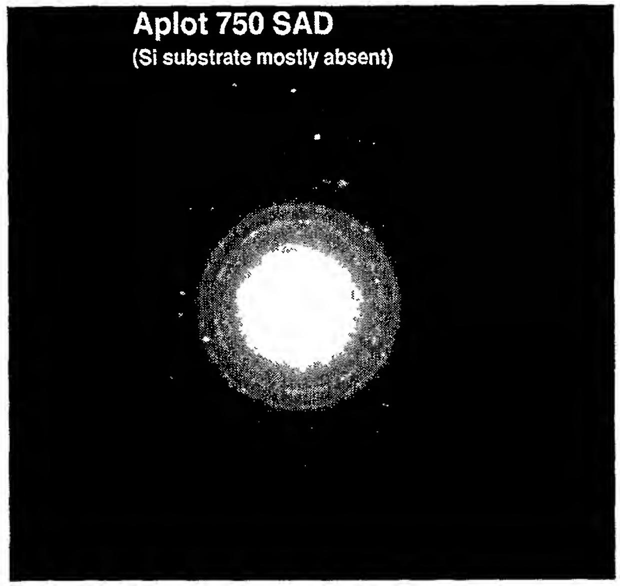


FIGURE 18

CROSS SECTION OF CONFORMAL AMORPHOUS SILICON FILM

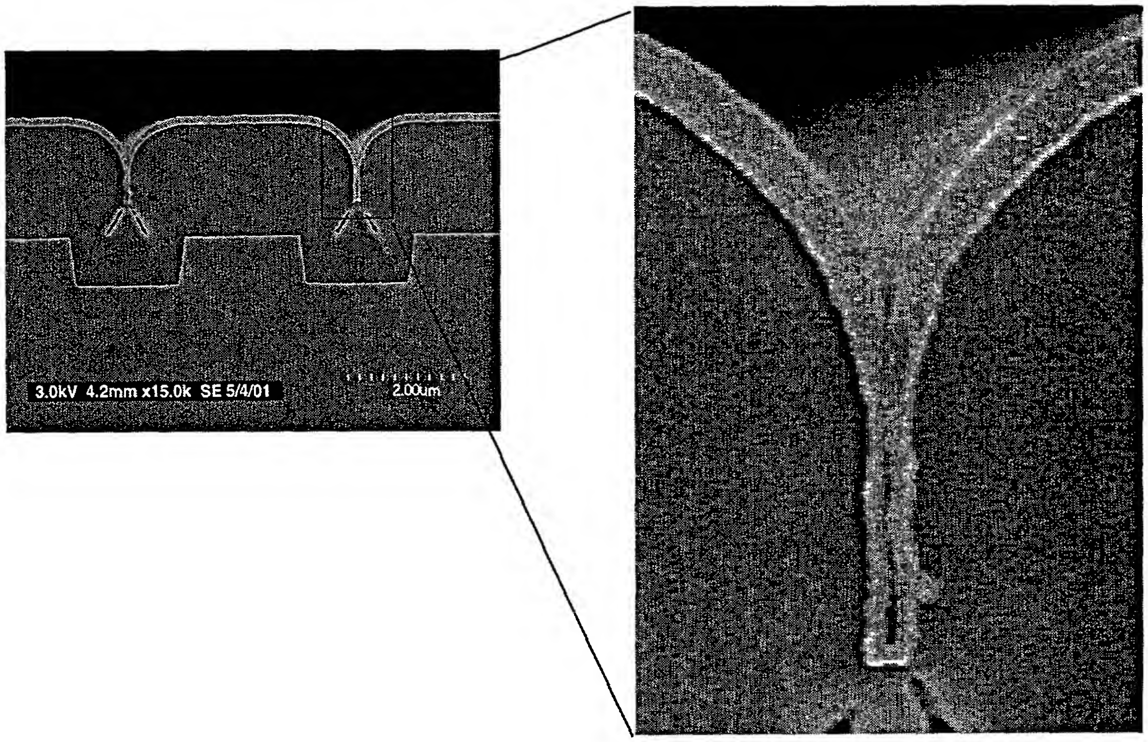


FIGURE 19

RBS SPECTRUM OF SILICON NITRIDE FILM

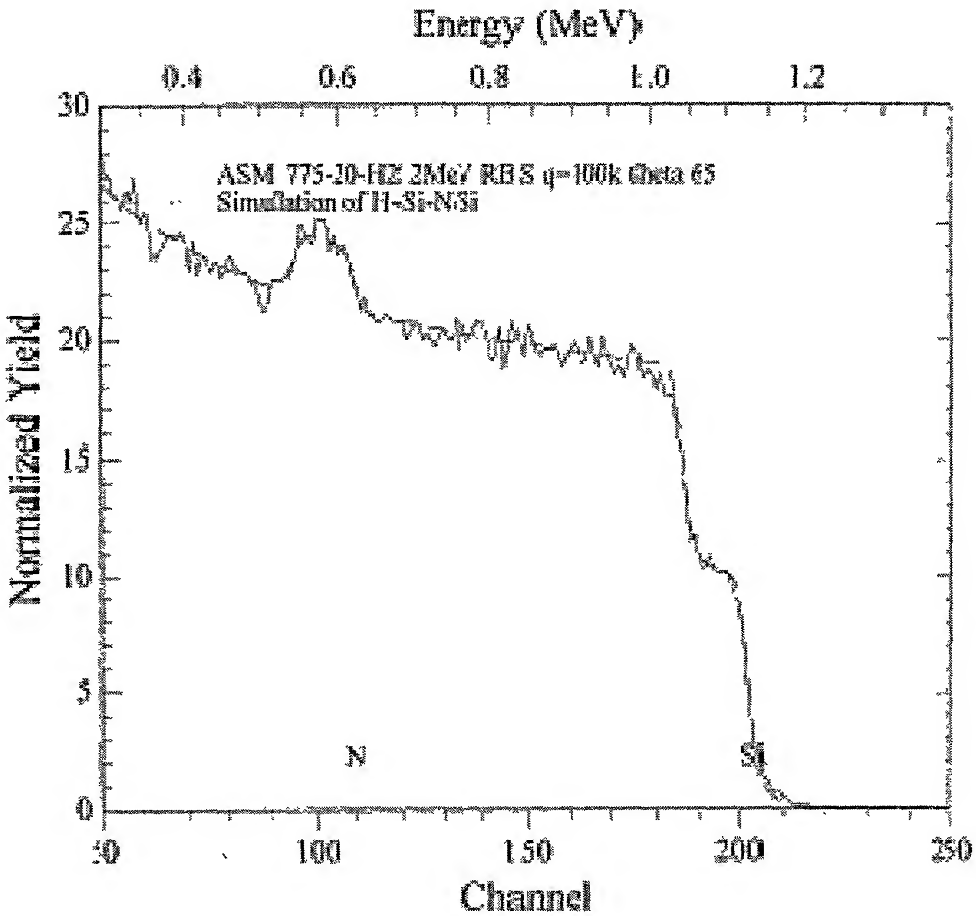


FIGURE 20

RBS ERD SPECTRUM OF SILICON NITRIDE FILM